ISSN 1324-5910

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DISCUSSION PAPERS IN ECONOMICS, FINANCE AND INTERNATIONAL COMPETITIVENESS

Short and Long-Term Price Linkages Among Asia-Pacific Economic Cooperation (APEC) Equity Markets

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Discussion Paper No. 100, February 2002

Series edited by
Dr Andrew Worthington

School of Economics and Finance

Short and Long-Term Price Linkages Among Asia-Pacific Economic Cooperation (APEC) Equity Markets

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Abstract

This paper examines the short and long-term price linkages among Asia-Pacific Economic Cooperation (APEC) equity markets over the period 1995 to 2000. Seven developed markets (Australia, Canada, Hong Kong, Japan, New Zealand, Singapore and the United States) and eleven emerging markets (China, Chile, Indonesia, Korea, Malaysia, Mexico, Peru, the Philippines, Russia, Taiwan and Thailand) are included in the analysis. Multivariate cointegration procedures, Granger-causality tests, level VAR and generalised variance decomposition analyses based on error-correction and vector autoregressive models are conducted to examine long and short-run relationships among these markets. The results indicate that there is a stationary long-run relationship and significant short-run causal linkages among the APEC equity markets. The results also indicate that the degree of comovement and codependencies among APEC's domestic and sub-regional markets varies considerably. In general, Australasian, Northern Asian and South American markets are relatively more influenced by domestic market conditions, North American markets relatively more by regional factors and Southern Asian markets more strongly influenced by markets outside either their own or geographical close domestic markets.

JEL classification: C32, F36, G15
Keywords: Cointegration; regional equity markets; APEC

1. INTRODUCTION

Asia-Pacific Economic Cooperation (APEC) was established in 1989 in response to the growing interdependence among Asia-Pacific economies. Initially an informal dialogue group, APEC has since become the primary vehicle for promoting open trade and practical economic cooperation within the region. From twelve founding members in 1989 (Australia, Brunei Darussalam, Canada, Indonesia, Japan, Korea, Malaysia, New Zealand, the Phillipines, Singapore, Thailand and the United States), APEC's current twenty-one member economies (adding China, Hong Kong, Taiwan, Mexico, Papua New Guinea, Chile, Peru, Russia and Vietnam) have a combined GDP of USD18 trillion and account for over 43.85 percent of global trade. And while the APEC forum lacks the formal institutional framework of other regional organizations, such as the European Union (EU), the North American Free Trade Association (NAFTA) and ASEAN (Association of South-East Asian Nations), it has nevertheless recognised and reinforced the substantial and broad-based economic linkages that exist between APEC members, and the desirability of its membership to "…open their economies further to international trade and investment, and to strengthen domestic and

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international architectures underpinning international flows of goods, services and capital" (APEC, 2001).

Despite the overriding concern with recognising and promoting economic integration within APEC, very little empirical evidence exists concerning short and long-term market linkages between member economies. This is an important omission since notions of economic integration have obvious implications for comovements between capital markets, and ultimately for the behaviour of investor groups, and the free flow of investment and capital amongst APEC members. While international studies concerned with market linkages are relatively commonplace [see, for example, Arshanapalli and Doukas (1993), Masih and Masih (1999) and Cheung and Lai (1999)] and regional markets, especially in Europe (Abbott and Chow, 1993; Espitia and Santamaria, 1994; Akdogan, 1995; Meric and Meric, 1997) and Latin America (Chaudhuri, 1997; Christofi and Pericli, 1999) are subject to increasing attention, few studies have adopted an exclusively Asia-Pacific/Pacific-Basin regional perspective.

Moreover, even where Asia-Pacific/Pacific-Basin markets are examined in a broader multilateral context (that is, along with North American and European markets) there is generally an emphasis on the more developed economies. For example, Lai et al. (1993), Richards (1995) Solnik et al. (1996), Darbar and Deb (1997), Yuhn (1997) and Francis and Leachman (1998) only incorporated Japan in their studies of international stock market linkages, Ramchand and Susmel (1998) added Singapore and Hong Kong, while Kwan *et al*. (1995) also included Taiwan and Korea. The few studies that have directly addressed market linkages in the Asia-Pacific/Pacific-Basin area have likewise confined themselves to a small sub-set of markets. For example, Janakiramanan et al. (1998) included only Australia, Hong Kong, Indonesia, Japan, Malaysia, New Zealand, Singapore, Thailand and the United States, and Cheung and Mak (1992) added Taiwan and the Philippines. As far as the authors are aware, no study to date has examined capital market linkages across the broad spectrum of APEC member economies, encompassing both the developed markets of Australasia, Asia and North America, and the emerging markets of Asia and South America.

This is important because while global effects are expected to impact upon APEC, regional impacts are expected to be prevalent due to social, cultural, economic, political and geographical linkages. That is, groups like APEC may provide a situation where markets, especially emerging markets, are partially segmented from the world economy but fully integrated into regional groups. The APEC equity markets highlight several emerging market crises where equity returns experienced both rallies and collapses, and where these effects were more keenly felt in the smaller regional groups. For instance, the 1995 Mexican peso crisis produced a fundamental reevaluation of the risks associated with investing in emerging markets, and Latin American markets experienced dramatic declines in equity returns. However, Asian emerging markets were not initially affected. It their case it was the floating of the Thai baht in mid-1997 that led to a reassessment of prospects for Asian equity markets that quickly spread in the form of the Asian crises of 1997-1998. In this instance, while Asian equity markets experienced dramatic falls in annual equity returns (Korea –20.49%, Philippines –14.57% and Thailand –60.22%), Latin American markets (Chile 8.82%, Mexico 30.94% and Peru 24.30%) surged as recovery from the Mexican crisis continued (all returns for year ending June 1997). These figures are highly suggestive of the strong regional effects found among APEC equity markets.

The paper itself is divided into three main areas. The second section explains the methodology and data employed in the present analysis. The results are dealt with in the third section. The paper ends with some brief concluding remarks.

2. EMPIRICAL METHODOLOGY

The data employed in the study is composed of value-weighted equity market indices for eighteen APEC member markets; namely, Australia, Canada, China, Chile, Hong Kong, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Peru, the Philippines, Russia, Singapore, Taiwan, Thailand and the United States. Seven of these markets are categorised as 'developed' (Australia, Canada, Hong Kong, Japan, New Zealand, Singapore and the United States) and the remainder are regarded as 'emerging'. All data is obtained from Morgan Stanley Capital International (MSCI) and encompasses the period 3 November 1995 to 6 October 2000. MSCI indices are widely employed in the financial integration literature on the basis of the degree of comparability and avoidance of dual listing [see, for instance, Meric and Meric (1997), Yuhn (1997), Roca (1999) and Cheung and Lai (1991)]. Weekly data is specified. On one hand, it has been argued that "daily return data is preferred to the lower frequency data such as weekly and monthly returns because longer horizon returns can obscure transient responses to innovations which may last for a few days only" (Elyasiani et al., 1998: 94). However, Roca (1999: 505), amongst others, has countered, "…daily data are deemed to contain 'too much noise' and is affected by the day-of-the-week effect".

The paper investigates the integration among APEC equity markets as follows. To start with, the variance of a nonstationary series is not constant over time, conventional asymptotic theory cannot be applied for those series. Unit root tests of the null hypothesis of nonstationarity are conducted using the Augmented Dickey-Fuller (ADF) test. Following Engle and Granger (1987) suppose we have the set of *m* indices $y_t = [Y_{1t,} Y_{2t}, \Lambda , Y_{mt}]'$ such that all are I(1) and $b^{'} y_t = u_t$ is I(0), then b is said to be a cointegrated vector and $b^{'} y_t = u_t$ is called the cointegrating regression. The components of y_t are said to be cointegrated of order d, denoted by y_t ~ CI(d, b) where $d > b > 0$, if (i) each component of y_t is integrated of order d, and (ii) there exists at least one vector $b = (b_1, b_2, …., b_m)$, such that the linear combination is integrated of (d - b). By Granger's theorem, if the indices are cointegrated, they can be expressed in an Error Correction Model (ECM) encompassing the notion of a long-run equilibrium relationship and the introduction of past disequilibrium as explanatory variables in the dynamic behaviour of current variables. In order to implement the ECM, the order of cointegration must be known. A useful statistical test for determining the cointegration order proposed by Johansen (1991) and Johansen and Juselius (1990) is the trace test. For example, to test for no cointegrating relationship, r is set to zero and the null hypothesis is $H_0 : r = 0$ and the alternative is $H_1 : r > 0$. However, the Johansen (1991) test can be affected by the lag order. The lag order is determined by using both the likelihood ratio test and information criteria in VAR. The optimum number of lags to be used in the VAR models is determined by the likelihood ratio test statistic:

$$LR = (T - K)\ln\left(\left|\Sigma_0\right| / \left|\Sigma_A\right|\right) \tag{1}$$

where T is the number of observations, K denotes the number of restrictions, Σ denotes the determinant of the covariance matrix of the error term, and subscripts 0 and A denote the restricted and unrestricted VAR, respectively. LR is asymptotically distributed c^2 with degrees of freedom equal to the number of restrictions. The test statistic in (1) is used to test the null hypothesis of the number of lags being equal to *k*-1 against the alternative hypotheses that k = 2, 3, … and so on. The test procedure continues until the null hypothesis fails to be rejected, thereby indicating the optimal lag corresponds to the lag of the null hypothesis.

In order to examine the short-run relationships, Granger (1969) causality tests are specified. Essentially tests of the prediction ability of time series models, an index causes another index in the Granger sense if past values of the first index explain the second, but past values of the second index do not explain the first. Since the indices in question are cointegrated, Granger causality is tested using the ECM:

$$\Delta y_t = g_0 + \sum_{i=1}^{r} y_i \Theta_{t-1} + \sum_{i=1}^{m} g_i \Delta y_{t-i} + e_t \tag{2}$$

where Θ contains r individual error-correction terms, r are long-term cointegrating vectors via the Johansen procedure, y and g are parameters to be estimated, and all other variables are as previously defined.

One problem with a Granger causality test based on (2) is that it is affected by the specification of the model. ECM is estimated under the assumption of a certain number of lags and cointegrating equations, which means that the actual specification thereby depends on the pre-test unit root (ADF) and cointegration (Johansen) tests. To avoid possible pre-test bias, Toda and Yamamoto (1995) propose the level VAR procedure. Essentially, the level VAR procedure is based on VAR for the level of variables with the lag order p in the VAR equations given by $p=k+d_{max}$, where k is the true lag length and d_{max} is the possible maximum integration order of variables. Therefore, the estimated VAR is expressed as:

$$y_t = \hat{g}_0 + \hat{g}_1 t + \ldots + \hat{g}_q t^q + \hat{J}_1 y_{t-1} + \ldots + \hat{J}_k y_{t-k} + \ldots + \hat{J}_p y_{t-p} + \hat{e}_t , \tag{3}$$

where $t = 1, \ldots, T$ is the trend term and $\hat{g}_i, \hat{J}_j$ are parameters estimated by OLS. Note that d_{max} does not exceed the true lag length k. Equation (3) can be written as:

$$Y' = \hat{\Gamma}\Lambda + \hat{\Phi}X + \hat{\Psi}Z' + \hat{E}' \tag{4}$$

where $\hat{\Gamma} = (\hat{g}_0, \ldots, \hat{g}_q)$, $\Lambda = (t_1, \ldots, t_T)$ with $t_t = (1, t, , \ldots, t^q)$, $\hat{\Phi} = (\hat{J}_1, \ldots, \hat{J}_k)$, $\hat{\Psi} = (\hat{J}_{k+1}, \ldots, \hat{J}_p)$, $X = (x_1, \ldots, x_T)$ with $x_t = (y'_{t-1}, \ldots, y'_{t-k})'$, $Z = (z_1, \ldots, z_T)$ with $z_t = (y'_{t-k-1}, \ldots, y'_{t-p})'$ and $E = (\hat{e}_1, \ldots, \hat{e}_T)$. As restrictions in parameters, the null hypothesis $H_0 : f(f) = 0$ where $f = vec(\Phi)$ is tested by a Wald statistic defined as:

$$W = f(\hat{f})' \left[F(\hat{f}) \left\{ \hat{\Sigma}_e \otimes (X'QX)^{-1} \right\} F(\hat{f})' \right]^{-1} f(\hat{f}) \tag{5}$$

where $F(f) = \partial f(f) / \partial f'$, $\hat{\Sigma}_e = T^{-1}\hat{E}'\hat{E}$, $Q = \hat{Q}_t - \hat{Q}_t Z(Z'\hat{Q}_t Z)^{-1} Z'\hat{Q}_t$ and $\hat{Q}_t = I_T - \hat{\Lambda}(\hat{\Lambda}'\hat{\Lambda})^{-1}\hat{\Lambda}'$

where I_T is a $T \times T$ identity matrix. Under the null hypothesis, the Wald statistic (5) has an asymptotic chi-square distribution with m degrees of freedom that corresponds to the number of restrictions. Although Toda and Yamamoto (1995) present this method principally for the purpose of Granger-causality testing, tests based on level VAR equations can also be used to examine long-run relationships. Test results based on the ECM can then be regarded as an indicator of short-run causality, while the causality tests by the level VAR can complement the result of the cointegration tests in terms of long-run information.

One limitation of these tests is that while they indicate which markets Granger-cause a given market, they do not indicate whether yet other markets can influence a given market through other equations in the system. Likewise, Granger causality does not provide an indication of the dynamic properties of the system, nor does it allow the relative strength of the Granger-causal chain to be evaluated. However, decomposition of the variance of forecast errors of a given market allows the relative importance of the variance markets in causing fluctuations in that market to be ascertained. The decomposition process therefore allows the variance of the forecast errors to be divided into percentages attributable to innovations in all other markets and a percentage attributable to innovations in the given market. One problem here is that the decomposition of variances is sensitive to the assumed origin of the shock and to the order it is transmitted to other markets. To overcome this problem, a generalised impulse response analysis, which is not subject to any arbitrary othogonalisations of innovations in the system, is applied (Masih and Masih, 1999).

The variance decomposition analysis illustrates the system dynamics by decomposing the random variation of one market into component shocks and analysing how these shocks in turn affect prices in other markets. Consider the following VAR model of m equity indices proposed by Eun and Shim (1989: 243):

$$y_t = \alpha + \sum_{S=1}^{n} A(S) y_{t-S} + e_t \qquad (6)$$

where y_t is a $m\times 1$ vector of indices, α and $A(S)$ are respectively $m\times 1$ and $m\times m$ coefficients, n is the lag length, and e_t is a $m\times 1$ column of forecast errors of the best linear predictor of y_t using past values of y. By construction, if the forecast error e_t is uncorrelated with all past values of y and is also a linear combination of current and past y_t, then e_t is serially uncorrelated. The i,j component of $A(S)$ measures the direct effect of the jth market on the ith market in S periods. As shown by Sim (1980), by the successive substitution of $e_t s$ into y_{t-S}, the VAR model becomes the following moving average representation where the price of each market is a function of past innovations of other markets:

$$y_t = \sum_{S=0}^{\infty} B(S) e_{t-S} \qquad (7)$$

Since e_t is serially uncorrelated, the components of e_t may be contemporaneously correlated. To observe the structure of the response of each market to a unit shock in another market within S periods, the error term is transformed by the triangular orthogonalisation procedure. Let $e = Vu$ where V is a lower triangle matrix and u is an orthogonalised innovation from e such that $Eee¢ = S$ and $VV¢ = S$ and the transformed innovation u_t has an identity covariance matrix. Equation (7) can then be re-written as:

$$y_t = \sum_{S=0}^{\infty} B(S)Vu_{t-S} = \sum_{S=0}^{\infty} C(S)u_{t-S} \quad (8)$$

where *C(S)* = *B(S)V*. The *i.j*th component of *C(S)* represents the impulse response of the *i*th market in *S* periods to a shock of one standard error in the *j*th market. From the orthogonalised innovations, the forecast variance of each market can also be decomposed into portions accounted by shocks or innovations from other markets. The orthogonalisation generates the quantity $\sum_{S=0}^{T} C_{ij}^2(S)$, which is the proportion of forecast error variance of y_i due to innovations in y_j. This variance decomposition provides a measure of the overall relative importance of the markets in generating fluctuations in both their own and other markets.

3. EMPIRICAL RESULTS

ADF unit root tests of the null hypothesis of nonstationarity are performed on each of the eighteen APEC equity indices in price level and price-differenced forms. Analysis of the price levels series indicates non-stationarity for all markets. However, all of the ADF test statistics are significant at the 0.01 level in first differenced form, indicating stationarity and the suggestion that each index series is integrated of order 1 or I(1). The finding of non-stationarity in levels and stationarity in differences provides comparable Asia-Pacific evidence to Elyasiani et al. (1998) and Masih and Masih (1999) amongst others. The differenced series are then used to carry out lag length selection, causality tests and decomposition of the forecast error variance for the markets analysed.

Johansen cointegration tests are used in order to obtain the cointegration rank. Eigenvalues and trace test statistics are detailed in Table 1 for the various null and alternative hypotheses. As multivariate cointegration tests cover all markets rather than simple bivariate combinations they therefore consider the wide range of portfolio diversification options available to non-APEC market investors, as well as the scope of financial integration that may not be reflected in pairwise combinations. The trace test statistic is greater than the critical value for the null hypotheses of r = 0 thereby rejecting the null hypothesis. However, the null hypothesis of r ≤ 1 fails to be rejected in favour r > 1 indicating the order of cointegration is 1. However, similar hypothesis are rejected up to, but not including, r ≤ 9 thereby suggesting an order of integration of nine. The primary finding obtained from the Johansen cointegration tests is that a stationary long-run relationship exists between APEC equity markets.

<TABLE 1 HERE>

Since cointegration exists, Granger causality tests are performed on the basis of equation (2). *F*-statistics are calculated to test the null hypothesis that the first index series does not Granger-cause the second, against the alternative hypothesis that the first index Granger-causes the second. Calculated statistics and *p*-values for the markets are detailed in Table 2. Among the eighteen APEC markets forty-eight significant causal links are found (at the .10 level or lower). For example, column 15 shows that the Australian, Indonesian, Malaysian, Mexican, Taiwan, Thailand and the US markets affect the Singaporean market. Japan (column 7) is found to have a Granger causal relationship with China, Hong Kong, Peru, Singapore and Taiwan.

Further insights are gained by examining the rows in Table 2 indicating the effects of a particular market on all markets. It is evident that the Thai market is the most influential market in the APEC member markets, influencing Australia, Chile, Indonesia, Korea, Mexico and Singapore. Thailand is followed by Japan, which Granger causes five markets: namely, Canada, Korea, Peru, Thailand and the US. The least influential markets in terms of Granger-causality include Canada, Indonesia and Russia.

<TABLE 2 HERE>

It is generally expected that the US market will dominate most other markets with little influence exerted by these markets on the US market. The Granger causality statistics indicates that the US market plays an important role in the Australian, Hong Kong, Peruvian and Singaporean markets, yet the US market is only influenced by Japan. Kwan (1995) also used Granger causality tests to conclude that none of the eight markets examined Granger-causes US stocks, but the US stock markets lead four markets (Australia, Japan, Hong Kong and the UK).

There is also an indication that there is feedback at play in several pairwise combinations. For example, Singapore Granger-causes the Malaysian market and Malaysia Granger-causes the Singaporean market. Janakiramannan (1998) used similar techniques to illustrate that Singapore and Malaysia exhibited high levels of market linkages because of the presence of similar investor groups and multi-listed companies. One implication of the results in Table 2 is that there may be no gains from pairwise portfolio diversification between those countries where a significant causal relationship exists. Also since we have a finding of causality these markets must be seen as violating weak-form efficiency since one of the markets can help forecast the other. In all other cases, the absence of Granger causality implies that there are sufficient short-run differences between the markets for non-Asian investors to gain by portfolio diversification.

The long-run causality Wald test statistics and *p*-values based on Toda and Yamamoto's (1995) level VAR procedure are presented in Table 3. The model is estimated for the levels, such that a significant Wald test statistic indicates a long-term relationship. This serves to supplement the findings obtained from the Granger causality (short run) results in Table 2. Among the eighteen markets, eighty-two significant causal links are found (at the 10 percent level or lower). For example, column 7 shows that the Canadian, Hong Kong, Indonesian, Malaysian, Russian, Singaporean, Taiwanese and Thailand markets affect the Japanese market; and the Philippine market (column 13) is influenced by Japan. The rows in Table 3 indicate the effects of a particular market on all markets. It is evident that the Thailand market is the most influential market in the APEC member equity markets, influencing Australia, Canada, Chile, China, Japan, Mexico, Russia, Taiwan and the United States. The least influential market is Singapore.

<TABLE 3 HERE>

However, these results should be interpreted with the qualification that Granger causality tests only indicate the most significant direct causal relationship. For example, it may be that some markets influence non-Granger caused markets indirectly through other markets. In order to address this concern, Table 4 presents the decomposition of the forecast error variance for 2-week, 4-week and 12-week ahead horizons for the APEC member equity markets. Each row indicates the percentage of forecast error variance explained by the market indicated in the first column. For example, at the 2-week horizon, the variance in the Australian market explains 91.54 percent of its own innovations, whereas 1.48 percentage of variance is explained by innovations in the Korean market, 1.32 percent by the Hong Kong and Malaysian markets and 1.05 percent by the US market. All APEC home markets explain at least 50 percent of their own innovations with the exception of Singapore and the US. Singapore influences some 40 percent of its own innovations and the US only 29 percent. The US market significantly influences the Canadian market by 47 percent, even after 24 weeks. It is readily apparent from the decomposition of the forecast error variance in Table 4 that sizeable differences in the percentage of variance explained by domestic and international markets prevail across APEC member markets.

It is obvious that the results of the long run causality tests and the variance decomposition are coupled with the more usual trade linkages along with the increasing financial linkages associated with the 1990s. In terms of merchandise trade alone several differences are noted. For example, in Indonesia all other APEC markets explain more of the non-domestic forecast error variance than other regional markets. This clearly reflects the fact that while 74 percent of Indonesia's merchandise exports and 68 percent of imports are to APEC, less than 14 percent of exports and 20 percent of imports are to nearby ASEAN markets. The reverse holds for Peru where almost equal amounts of forecast error variance are from regional as all other markets reflecting the fact that while 55 percent of merchandise exports and 22.06 percent of imports are to APEC markets, most of this is concentrated in other Latin American APEC economies. The results also highlight the interdependencies among, say, Asian equity markets in the post-crises period. Traditionally, most Asian markets have been regarded as relatively isolated, but the percentage of forecast error variance attributable to markets outside the domestic market suggests this has increased substantially. Similarly, the number of markets accounting for relatively larger shares of forecast variance across all markets is also relatively large, suggesting that innovations in many more markets are responsible for market changes than had been the case before the onset of the Asian financial crises in 1997.

<TABLE 4 HERE>

In order to further examine these differences, Table 5 summarises the forecast variance decomposition for each APEC member market and for various categories of markets. Each market is initially categorised as either an 'emerging' or 'developed' market. The seven developed markets comprise Australia, Canada, Hong Kong, Japan, New Zealand, Singapore and United States and the eleven emerging markets include China, Chile, Indonesia, Korea, Malaysia, Mexico, Peru, the Philippines, Russia, Taiwan, and Thailand. Each market is then linked with markets in close geographic proximity: 'Australasia' includes Australia and New Zealand, 'Northern Asia' is composed of China, Hong Kong, Japan, Korea, Russia and Taiwan, 'Southern Asia' represents Indonesia, Malaysia, Philippines, Singapore and Thailand, 'North America' consists of Canada, USA and Mexico and 'South America' takes in Chile and Peru. Masih and Masih (1999) and Chritofi and Pericli (1999), amongst others, have all examined international equity market integration from a strong regional perspective.

<TABLE 5 HERE>

Starting with the emerging/developed market division, we can see that relatively more variance in emerging markets is explained by innovations in the domestic market (66.54 percent) and relatively less by innovations in the regional market (10.96 percent) when compared to developed markets (63.78 and 13.94 percent respectively). The percentage of forecast error variance explained by non-domestic, non-regional innovations is approximately the same for both categories. This accord with the view that despite particular 'wake-up call' events like the Mexican and Asian financial crises, for the most part emerging markets are much more isolated than developed markets. However, sizeable disparities also exist across regional combinations. For example, Australasian (83.41 percent), Northern Asian (72.53 percent) and South American (68.43 percent) markets are relatively more influenced by innovations from the domestic market, while the North American markets (51.48 percent) are relatively less so. However, the North American markets (24.47 percent) have the highest proportion of forecast error variance explained by regional markets. This is thought to reflect the very strong trade links associated with NAFTA. On the other hand, the Southern Asian regional markets are strongly influenced by innovations in markets outside either their own or geographical close domestic markets. This of course indicates the fact that most of these markets have relatively more exposure in terms of both trade and capital flows to distant APEC economies, especially the United States in the form of non-oil domestic exports such as integrated circuits, computer parts and telecommunications equipment. Of course, care should be taken in generalising these results. For example, developed markets dominate the North American and Australasian market categories, while the South American category is composed entirely of emerging markets.

4. CONCLUDING REMARKS

This paper investigates long-term and short-term relationships among eighteen APEC member equity markets during the period 1995 to 2000. Seven of these markets are regarded as developed (Australia, Canada, Hong Kong, Japan, New Zealand, Singapore and the US) while the remainder are categorised as emerging markets (namely, China, Chile, Indonesia, Korea, Malaysia, Peru, the Philippines, Russia, Taiwan and Thailand). Multivariate cointegrating techniques are used to establish long-term relationships among these markets and Granger causality tests are used to measure causal relationships in the short-term within an error-correcting model (ECM). The results indicate, as expected, that the various equity markets are highly integrated. This could attributed, at least in part, to the efforts APEC Members have made to open their economies to international trade and investment and to strengthen domestic and international ties underpinning the international flow of goods, services and capital. In fact, most of the differences in the causal relationships and the percentage of forecast variance explained by domestic, regional and all other markets can be explained by differences in trade and capital flows.

The findings obtained in this paper highlight some interesting disparities in the extent of market integration among the APEC member equity markets. While domestic markets are highly associated with innovations occurring in other regional markets, low causal relationships exist for the equity markets in Canada, Indonesia, Russia China, Chile, Malaysia, Mexico, Peru, the Philippines and Singapore. This is further reinforced by the results of a decomposition of variance analysis that indicate that a distinguishing characteristic of some markets is the extremely low level of variance explained by other markets, while in other sub-regional factors are considerably more important than in others. These factors together pose particular challenges for APEC member economies in the conduct of policy and efforts to build upon the gains in economic integration from recent years.

These results are also of interest to portfolio managers. Investment in emerging equity markets is often encouraged because of relatively low correlation with developed equity markets. It may be the case that trading groups like APEC provide a situation where emerging markets are indeed partially segmented from the global economy but fully integrated into smaller regional groups. Among the many emerging market in the Asia-Pacific region it may be the case that diversification benefits are possible in general, but that at the regional level such opportunities are more limited, because of the existing level of trade flows and the increasing level of financial integration in the 1990s.

Of course, there are a number of limitations in this paper, and these highlight possible avenues of future research. One development could investigate the presence of volatility effects in equity prices attributable to uncertainties in the price fluctuations themselves. These in turn would reflect informational flows, central bank intervention in emerging as well global markets, political noise and various international industry effects found in the Asia-Pacific region. Accordingly, this work could avail itself of the sizeable advances in autoregressive conditional heteroskedastic (ARCH) models to study the conditional volatility of stock markets and ascertain the predicatability of future stock return volatility conditional on past volatilities and return shocks, especially with extensions to the multivariate case

ACKNOWLEDGEMENTS

The authors would like to thank Masaki Katsuura and an anonymous referee for helpful comments on an earlier version of this paper.

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Table 1
Johansen cointegration tests for APEC Member markets

H_0	H_1	*Eigenvalue*	*Trace test*
r = 0	r > 0	0.378	868.790*
r ≤ 1	r > 1	0.307	747.250*
r ≤ 2	r > 2	0.296	653.085*
r ≤ 3	r > 3	0.260	563.073*
r ≤ 4	r > 4	0.247	485.724*
r ≤ 5	r > 5	0.230	413.033*
r ≤ 6	r > 6	0.203	345.878*
r ≤ 7	r > 7	0.185	287.779*
r ≤ 8	r > 8	0.177	235.112*
r ≤ 9	r > 9	0.133	185.238
r ≤ 10	r > 10	0.116	148.487
r ≤ 11	r > 11	0.099	116.655
r ≤ 12	r > 12	0.092	89.799
r ≤ 13	r > 13	0.080	64.940
r ≤ 14	r > 14	0.072	43.406
r ≤ 15	r > 15	0.059	24.177
r ≤ 16	r > 16	0.030	8.548
r ≤ 17	r > 18	0.002	0.678
Accepted			9

Notes: Critical values from Osterwald-Lenum (1992), an asterisk indicates significance at the .05 level; the optimal lag order of each VAR model was selected using LR tests for the significance of the coefficient for maximum lags and Schwarz's Bayseian Information Criterion; in each cointegrating equation, the intercept (no trend) is included which is selected by AIC.

Table 2
Granger causality tests for eighteen APEC Member markets for the period 3 November 1995 to 6 October 2000: Weekly data

	AUS	CAN	CHI	CHL	HON	INDO	JAP	KOR	MAL	MEX	NZL	PER	PHI	RUS	SIN	TAI	THA	USA	Causes
AUS	–	1.5236	0.5930	3.5654	0.0501	2.2355	0.6235	2.6168	0.7240	6.8315	0.0605	1.6968	0.4681	2.3878	3.6690	0.4701	0.0826	2.0715	3
		(0.2183)	(0.4420)	**(0.0602)**	(0.8231)	(0.1362)	(0.4305)	(0.1071)	(0.3957)	**(0.0095)**	(0.8060)	(0.1940)	(0.4945)	(0.1236)	**(0.0566)**	(0.4936)	(0.7740)	(0.1514)	
CAN	4.3272	–	1.4153	0.0150	0.0191	0.0970	0.7208	1.7926	0.1911	0.2376	0.0291	0.3665	0.2689	0.3081	2.0816	0.4362	0.0372	0.1264	1
	(0.0386)		(0.2354)	(0.9027)	(0.8903)	(0.7557)	(0.3967)	(0.1819)	(0.6624)	(0.6264)	(0.8647)	(0.5455)	(0.6045)	(0.5794)	(0.1504)	(0.5096)	(0.8473)	(0.7225)	
CHI	1.1488	0.0116	–	0.0744	4.5023	0.5092	3.2870	0.6298	0.0188	0.1540	0.0994	1.0449	0.8525	0.0942	1.6062	1.2426	0.3861	0.0733	2
	(0.2849)	(0.9144)		(0.7853)	**(0.0349)**	(0.4762)	**(0.0711)**	(0.4282)	(0.8911)	(0.6951)	(0.7528)	(0.3077)	(0.3568)	(0.7592)	(0.2063)	(0.2661)	(0.5350)	(0.7869)	
CHL	0.7048	0.1315	1.3042	–	0.9695	0.3637	0.0173	0.0257	5.0098	0.1868	2.0834	0.0148	0.1758	0.8549	1.0278	2.4330	3.1696	0.1133	2
	(0.4020)	(0.7172)	(0.2546)		(0.3258)	(0.5470)	(0.8955)	(0.8727)	**(0.0261)**	(0.6660)	(0.1502)	(0.9031)	(0.6754)	(0.3561)	(0.3117)	(0.1201)	**(0.0763)**	(0.7367)	
HON	1.9441	4.3749	7.6013	0.7861	–	0.6591	7.0083	0.0904	0.0221	0.3729	0.1196	0.0267	5.6125	0.0536	2.3482	0.7376	0.0436	0.0027	4
	(0.1645)	**(0.0375)**	**(0.0063)**	(0.3762)		(0.4177)	**(0.0087)**	(0.7639)	(0.8821)	(0.5420)	(0.7298)	(0.8703)	**(0.0186)**	(0.8172)	(0.1268)	(0.3913)	(0.8347)	(0.9587)	
IND	0.4034	0.0946	2.0919	0.0032	0.2122	–	0.0005	0.0559	0.0011	0.3473	0.3789	0.3827	0.4367	0.6088	3.6013	0.0137	0.6153	0.0126	1
	(0.5259)	(0.7587)	(0.1494)	(0.9547)	(0.6455)		(0.9814)	(0.8133)	(0.9732)	(0.5562)	(0.5388)	(0.5367)	(0.5094)	(0.4360)	**(0.0589)**	(0.9068)	(0.4336)	(0.9108)	
JAP	1.3464	3.3187	0.0269	0.1067	0.0215	1.4885	–	3.2790	0.2028	1.1623	0.3654	3.2502	0.7199	1.5289	0.0351	0.1555	3.8638	4.1527	5
	(0.2471)	**(0.0698)**	(0.8699)	(0.7442)	(0.8835)	(0.2237)		**(0.0714)**	(0.6529)	(0.2821)	(0.5461)	**(0.0727)**	(0.3970)	(0.2175)	(0.8516)	(0.6937)	**(0.0505)**	**(0.0427)**	
KOR	2.5016	0.4101	0.5698	2.8047	1.6558	2.7924	0.5752	–	1.0923	0.3921	0.0095	1.3193	0.1631	3.7360	0.0067	0.0493	2.6834	0.0617	3
	(0.1151)	(0.5225)	(0.4511)	**(0.0953)**	(0.1994)	**(0.0960)**	(0.4490)		(0.2970)	(0.5318)	(0.9224)	(0.2519)	(0.6866)	**(0.0544)**	(0.9350)	(0.8244)	(0.1027)	(0.8040)	
MAL	2.6164	0.2531	2.8109	0.2353	0.4283	1.3607	0.5871	0.1117	–	2.5762	0.5288	0.1696	0.2882	0.0056	3.2753	0.6814	1.3507	0.1456	2
	(0.1071)	(0.6154)	**(0.0949)**	(0.6281)	(0.5134)	(0.2446)	(0.4443)	(0.7385)		(0.1098)	(0.4678)	(0.6808)	(0.5918)	(0.9406)	**(0.0716)**	(0.4099)	(0.2463)	(0.7031)	
MEX	0.0605	0.2183	0.0003	0.4645	0.9448	2.0188	0.0526	0.6320	4.6981	–	0.0104	1.7996	1.9859	0.8760	8.0108	0.4182	1.2867	0.0000	2
	(0.8060)	(0.6407)	(0.9862)	(0.4962)	(0.3320)	(0.1567)	(0.8188)	(0.4274)	**(0.0312)**		(0.9190)	(0.1810)	(0.1601)	(0.3502)	**(0.0050)**	(0.5184)	(0.2578)	(0.9970)	
NZL	0.8294	1.9212	4.6073	2.2260	0.1091	0.3787	0.2099	0.2291	1.7415	1.1132	–	0.6086	3.2982	3.1587	0.1597	2.5950	1.4742	0.3531	3
	(0.3634)	(0.1670)	**(0.0328)**	(0.1370)	(0.7414)	(0.5389)	(0.6472)	(0.6327)	(0.1882)	(0.2925)		(0.4361)	**(0.0706)**	**(0.0768)**	(0.6898)	(0.1085)	(0.2259)	(0.5529)	
PER	0.0611	0.0318	0.0012	0.0480	0.1396	0.0069	4.6246	0.3045	0.0279	2.7438	1.3717	–	2.0738	1.4172	0.2131	0.1340	0.1853	0.9156	2
	(0.8050)	(0.8587)	(0.9723)	(0.8268)	(0.7090)	(0.9339)	**(0.0325)**	(0.5816)	(0.8676)	**(0.0989)**	(0.2427)		(0.1512)	(0.2351)	(0.6448)	(0.7146)	(0.6672)	(0.3396)	
PHI	1.1334	0.5553	3.7244	0.1738	0.0800	1.4649	0.7657	0.2665	0.0081	0.4731	0.0128	3.3202	–	0.2425	0.3239	0.0395	0.4010	0.6866	2
	(0.2881)	(0.4569)	**(0.0548)**	(0.6771)	(0.7776)	(0.2273)	(0.3824)	(0.6062)	(0.9282)	(0.4922)	(0.9100)	**(0.0697)**		(0.6229)	(0.5698)	(0.8426)	(0.5272)	(0.4081)	
RUS	0.4485	0.4861	0.3289	0.0000	0.5664	0.2230	0.2091	0.7210	2.7545	0.0105	0.0203	0.0053	2.0803	–	0.0124	0.1043	0.9915	0.7592	1
	(0.5037)	(0.4864)	(0.5669)	(1.0000)	(0.4524)	(0.6372)	(0.6479)	(0.3967)	**(0.0983)**	(0.9183)	(0.8867)	(0.9421)	(0.1505)		(0.9113)	(0.7471)	(0.3204)	(0.3845)	
SIN	0.0431	0.2216	1.2363	0.0213	0.7139	1.0758	2.9671	0.6792	3.2074	0.9125	0.4865	0.1411	0.0350	1.8114	–	0.3287	0.2335	0.4290	2
	(0.8356)	(0.6382)	(0.2673)	(0.8841)	(0.3990)	(0.3007)	**(0.0863)**	(0.4107)	**(0.0746)**	(0.3404)	(0.4862)	(0.7076)	(0.8518)	(0.1796)		(0.5670)	(0.6294)	(0.5131)	
TAI	0.1784	0.0289	0.1594	1.8606	0.4697	1.4455	2.8632	0.0423	0.0021	0.3048	0.0771	0.6365	0.0216	4.0507	7.4260	–	0.1070	0.1249	3
	(0.6731)	(0.8651)	(0.6901)	(0.1738)	(0.4938)	(0.2304)	**(0.0919)**	(0.8371)	(0.9633)	(0.5814)	(0.7815)	(0.4258)	(0.8832)	**(0.0453)**	**(0.0069)**		(0.7439)	(0.7241)	
THA	4.0929	0.0078	0.7963	3.5589	0.4735	5.1194	0.4553	8.9429	0.5509	3.4919	0.1943	0.0062	0.0907	0.8993	4.2621	1.3322	–	0.3615	6
	(0.0442)	(0.9298)	(0.3731)	**(0.0604)**	(0.4920)	**(0.0246)**	(0.5005)	**(0.0031)**	(0.4587)	**(0.0629)**	(0.6598)	(0.9372)	(0.7635)	(0.3439)	**(0.0401)**	(0.2496)		(0.5483)	
USA	3.1678	0.0323	0.0690	1.3580	4.6350	0.8056	0.5127	2.3854	2.6446	0.0349	0.1622	3.9591	1.8506	0.1079	7.7386	0.1450	0.2826	–	4
	(0.0764)	(0.8576)	(0.7930)	(0.2450)	**(0.0323)**	(0.3703)	(0.4747)	(0.1238)	(0.1052)	(0.8519)	(0.6875)	**(0.0478)**	(0.1750)	(0.7428)	**(0.0058)**	(0.7037)	(0.5955)		
Caused	3	2	4	3	2	2	5	2	4	3	0	3	2	3	7	0	2	1	48

Notes: Granger causality tests are conducted by adjusting the long-term cointegrating relationship by the ECM; figures in brackets are p-values; tests indicate Granger causality by row to column and Granger caused by column to row, for example, in the period 3/11/1995 – 6/10/2000 Australia (row) Granger causes three markets (Chile, Mexico and Singapore) and is Granger caused by Canada, Thailand and the US (using a critical value of .10).

Table 3
Long-run causality test by level-VAR for eighteen APEC markets for the period 3 November 1995 to 6 October 2000: Weekly data

	AUS	CAN	CHI	CHL	HON	INDO	JAP	KOR	MAL	MEX	NZL	PER	PHI	RUS	SIN	TAI	THA	USA	Causes
AUS	–	15.3924	9.2866	11.9361	10.0843	7.4392	15.2169	13.2430	8.6413	13.0516	10.2025	16.5491	11.0744	9.8097	8.4951	34.8296	11.1960	25.0547	3
		(0.1184)	(0.5051)	(0.2894)	(0.4331)	(0.6834)	(0.1244)	(0.2104)	(0.5665)	(0.2208)	(0.4229)	**(0.0850)**	(0.3518)	(0.4573)	(0.5806)	**(0.0001)**	(0.3425)	**(0.0052)**	
CAN	40.6556	–	5.4827	5.4509	9.2470	1.8743	22.0267	8.5755	6.8184	6.6541	16.2150	17.5876	7.5358	21.9672	3.9116	22.8719	13.3285	8.4548	6
	(0.0000)		(0.8567)	(0.8591)	(0.5088)	(0.9972)	**(0.0150)**	(0.5728)	(0.7425)	(0.7576)	**(0.0936)**	**(0.0623)**	(0.6741)	**(0.0153)**	(0.9512)	**(0.0112)**	(0.2059)	(0.5845)	
CHI	5.0382	13.9871	–	13.2251	27.2054	10.6276	8.6600	18.1381	15.8467	12.9707	3.9643	15.3208	13.0002	21.9718	15.3812	21.8290	5.8126	20.3923	5
	(0.8886)	(0.1736)		(0.2114)	**(0.0024)**	(0.3873)	(0.5646)	**(0.0527)**	(0.1041)	(0.2253)	(0.9489)	(0.1208)	(0.2237)	**(0.0152)**	(0.1188)	**(0.0160)**	(0.8308)	**(0.0258)**	
CHL	19.8979	16.0221	4.8366	–	6.2810	4.1947	9.0556	6.3915	6.1428	12.7123	11.1350	18.4705	4.2353	17.6766	2.8090	28.0221	9.7148	24.8116	6
	(0.0302)	**(0.0990)**	(0.9018)		(0.7911)	(0.9381)	(0.5268)	(0.7814)	(0.8031)	(0.2402)	(0.3471)	**(0.0475)**	(0.9361)	**(0.0607)**	(0.9856)	**(0.0018)**	(0.4659)	**(0.0057)**	
HON	5.5424	9.8873	7.0764	8.0197	–	1.8598	19.5842	4.2316	11.4934	4.8646	4.2407	8.3516	5.6010	17.7291	7.9304	13.5215	6.2187	15.2833	2
	(0.8521)	(0.4504)	(0.7182)	(0.6269)		(0.9973)	**(0.0334)**	(0.9363)	(0.3204)	(0.9000)	(0.9358)	(0.5945)	(0.8476)	**(0.0597)**	(0.6356)	(0.1960)	(0.7966)	(0.1221)	
IND	7.0307	11.0398	8.5087	13.8666	5.8480	–	26.2051	13.9021	8.9998	12.0354	25.1974	10.4957	4.0994	21.2142	9.4571	22.5362	4.7945	11.0319	4
	(0.7225)	(0.3544)	(0.5793)	(0.1792)	(0.8279)		**(0.0035)**	(0.1775)	(0.5321)	(0.2827)	**(0.0050)**	(0.3981)	(0.9428)	**(0.0196)**	(0.4893)	**(0.0126)**	(0.9045)	(0.3550)	
JAP	20.8787	16.2029	7.0154	6.8481	18.8360	10.6145	–	15.9353	17.0640	6.2848	6.3209	11.5630	19.8437	9.9109	11.9075	19.4361	8.2249	12.5161	6
	(0.0220)	**(0.0940)**	(0.7240)	(0.7397)	**(0.0424)**	(0.3883)		(0.1015)	**(0.0730)**	(0.7908)	(0.7876)	(0.3154)	**(0.0308)**	(0.4483)	(0.2913)	**(0.0351)**	(0.6069)	(0.2520)	
KOR	15.0851	29.2587	8.3195	6.2027	10.2733	13.1003	10.5440	–	22.1884	7.8493	18.9101	8.6712	6.2814	14.9110	6.7971	10.2719	7.8566	20.7353	4
	(0.1290)	**(0.0011)**	(0.5977)	(0.7980)	(0.4169)	(0.2181)	(0.3941)		**(0.0142)**	(0.6436)	**(0.0414)**	(0.5636)	(0.7911)	(0.1353)	(0.7444)	(0.4170)	(0.6428)	**(0.0230)**	
MAL	4.6900	4.9953	5.4714	12.1935	7.5497	7.9093	27.4738	27.7027	–	6.2563	19.1809	4.9092	6.2073	25.3247	13.3656	19.2214	10.2197	14.2966	5
	(0.9109)	(0.8915)	(0.8576)	(0.2723)	(0.6727)	(0.6377)	**(0.0022)**	**(0.0020)**		(0.7933)	**(0.0380)**	(0.8972)	(0.7976)	**(0.0048)**	(0.2039)	**(0.0375)**	(0.4214)	(0.1599)	
MEX	17.6877	23.8373	6.1389	13.0207	6.7242	3.2866	8.3777	19.6607	16.1154	–	7.9541	18.3984	12.4617	17.9348	10.9821	10.9160	14.2779	17.0851	7
	(0.0605)	**(0.0080)**	(0.8035)	(0.2225)	(0.7512)	(0.9739)	(0.5920)	**(0.0326)**	**(0.0964)**		(0.6333)	**(0.0486)**	(0.2553)	**(0.0561)**	(0.3589)	(0.3641)	(0.1607)	**(0.0725)**	
NZL	6.9803	9.4781	5.1040	15.0469	9.6776	8.1729	13.0549	5.4376	16.7668	19.2968	–	8.9786	10.3438	12.5687	9.0072	20.5253	10.1442	26.5876	4
	(0.7273)	(0.4874)	(0.8841)	(0.1304)	(0.4692)	(0.6120)	(0.2206)	(0.8601)	**(0.0797)**	**(0.0367)**		(0.5341)	(0.4109)	(0.2488)	(0.5314)	**(0.0247)**	(0.4279)	**(0.0030)**	
PER	10.8996	16.9166	4.0819	11.6147	21.5679	13.0673	13.8918	10.2961	8.0604	15.2599	11.9994	–	8.5438	14.1197	14.0855	5.2236	8.7379	27.7712	3
	(0.3654)	**(0.0762)**	(0.9436)	(0.3117)	**(0.0175)**	(0.2199)	(0.1780)	(0.4149)	(0.6229)	(0.1229)	(0.2851)		(0.5759)	(0.1676)	(0.1691)	(0.8757)	(0.5571)	**(0.0020)**	
PHI	6.0145	12.8293	7.1863	14.2485	17.2660	9.6488	8.4665	8.3019	6.9748	10.7947	5.3061	24.2804	–	12.9004	7.5305	14.7735	12.6961	12.3509	2
	(0.8140)	(0.2334)	(0.7077)	(0.1620)	**(0.0687)**	(0.4718)	(0.5834)	(0.5994)	(0.7278)	(0.3737)	(0.8698)	**(0.0069)**		(0.2293)	(0.6746)	(0.1405)	(0.2412)	(0.2623)	
RUS	16.8185	18.4395	15.4326	21.1873	7.0472	11.3367	18.0588	13.4465	5.2248	11.1857	12.3152	13.9830	14.1223	–	7.4133	33.5541	7.4851	17.5468	6
	(0.0785)	**(0.0480)**	(0.1171)	**(0.0198)**	(0.7210)	(0.3319)	**(0.0540)**	(0.1998)	(0.8757)	(0.3432)	(0.2645)	(0.1738)	(0.1675)		(0.6859)	**(0.0002)**	(0.6790)	**(0.0631)**	
SIN	15.0171	6.6233	9.1215	3.1689	5.1284	8.1426	18.4466	7.1594	5.1147	2.1321	15.3006	6.9554	7.7140	15.0604	–	6.2852	4.7637	6.8923	1
	(0.1314)	(0.7605)	(0.5206)	(0.9772)	(0.8824)	(0.6149)	**(0.0479)**	(0.7103)	(0.8834)	(0.9952)	(0.1215)	(0.7296)	(0.6568)	(0.1299)		(0.7908)	(0.9064)	(0.7356)	
TAI	7.1461	9.6607	7.0801	18.9150	15.3293	17.0657	17.8524	10.6298	10.3474	6.5766	7.3257	21.1534	15.4416	33.5029	10.1913	–	21.4026	16.2224	7
	(0.7116)	(0.4707)	(0.7179)	**(0.0414)**	(0.1205)	**(0.0729)**	**(0.0575)**	(0.3871)	(0.4106)	(0.7647)	(0.6944)	**(0.0200)**	(0.1168)	**(0.0002)**	(0.4239)		**(0.0185)**	**(0.0934)**	
THA	17.6773	18.5288	23.5450	17.2368	13.8115	12.4049	21.0314	3.5620	6.0746	20.8081	13.7474	11.0263	11.2127	17.5561	6.4421	22.3687	–	16.7206	9
	(0.0607)	**(0.0467)**	**(0.0089)**	**(0.0693)**	(0.1818)	(0.2589)	**(0.0209)**	(0.9650)	(0.8090)	**(0.0225)**	(0.1848)	(0.3555)	(0.3412)	**(0.0629)**	(0.7769)	**(0.0133)**		**(0.0808)**	
USA	14.1714	7.5734	3.2780	11.2855	8.2767	7.0520	7.4856	13.3989	19.0761	13.2804	23.9865	15.4088	5.7438	9.9260	6.6927	12.7377	10.5290	–	2
	(0.1653)	(0.6704)	(0.9741)	(0.3357)	(0.6018)	(0.7205)	(0.6789)	(0.2022)	**(0.0393)**	(0.2084)	**(0.0076)**	(0.1179)	(0.8363)	(0.4470)	(0.7541)	(0.2387)	(0.3954)		
Caused	6	4	1	3	4	1	8	3	5	2	5	6	1	9	0	10	1	10	82

Notes: Notes: Unbracketed figures in table are Wald statistics for Granger causality tests. Figures in brackets are *p*-values. The level VARs are estimated with lag order of $p = k + d_{max}$; k is selected by the LR test and d_{max} is set to one. Tests indicate Granger causality by row to column and Granger caused by column to row, for example, Hong Kong (row) Granger causes two markets (Japan and Russia) and is Granger caused by Chile, Japan, Peru and the Philippines (using a critical value of .10). Significant *p*-values are in bold.

Table 4
Generalised variance decomposition for APEC Member markets for the period 3 November 1995 to 6 October 2000: Weekly data

	SE	AUS	CAN	CHI	CHL	HON	IND	JAP	KOR	MAL	MEX	NZl	PER	PHI	RUS	SIN	TAI	THA	USA
AUS	3.6038	91.5418	0.0080	0.1285	0.0580	1.3175	0.0045	1.1993	1.4777	1.3234	0.1264	0.2802	0.0663	0.0525	0.2517	0.0456	0.0731	0.9932	1.0521
	3.6479	89.6904	0.0733	0.1899	0.6293	1.4896	0.0084	1.1823	1.7823	1.2925	0.1360	0.8515	0.1028	0.1188	0.2555	0.0623	0.0718	1.0176	1.0456
	3.6485	89.6616	0.0793	0.2000	0.6292	1.4916	0.0089	1.1856	1.7866	1.2923	0.1361	0.8516	0.1029	0.1189	0.2561	0.0626	0.0719	1.0186	1.0462
CAN	20.0889	20.4963	73.6053	0.4411	0.5086	2.1377	0.0210	1.0972	0.1623	0.0007	0.0765	0.9482	0.0008	0.2542	0.1463	0.0754	0.0127	0.0046	0.0110
	20.3150	20.5566	72.4264	0.8275	0.5352	2.3448	0.0379	1.3089	0.1683	0.0228	0.0758	1.0717	0.0322	0.2683	0.1505	0.0808	0.0151	0.0610	0.0162
	20.3222	20.5672	72.3820	0.8381	0.5357	2.3438	0.0380	1.3272	0.1689	0.0230	0.0763	1.0711	0.0332	0.2682	0.1505	0.0827	0.0164	0.0611	0.0164
CHI	2.7951	0.2643	1.2127	90.5483	0.7039	1.8617	0.3159	0.1964	0.3480	0.1939	0.0354	2.3954	0.0006	1.1703	0.1011	0.3112	0.0682	0.2486	0.0240
	2.8290	0.2624	1.3538	88.8463	0.7110	2.2432	0.3990	0.2666	0.5729	0.3242	0.0360	2.6049	0.0237	1.1918	0.3359	0.3064	0.0942	0.3644	0.0635
	2.8301	0.2680	1.3577	88.7915	0.7108	2.2431	0.4019	0.2824	0.5839	0.3256	0.0361	2.6060	0.0238	1.1940	0.3359	0.3090	0.0985	0.3646	0.0672
CHL	21.1270	2.7408	11.7817	1.2197	79.0739	0.1457	0.0060	0.2569	1.4306	0.0088	0.0502	0.5928	0.0168	0.0119	0.1206	0.0440	0.5901	1.4470	0.4625
	21.1767	2.7425	11.7285	1.2501	78.7047	0.2018	0.0072	0.2574	1.5060	0.0267	0.0530	0.6801	0.0168	0.0392	0.1223	0.0730	0.6087	1.5020	0.4800
	21.1776	2.7430	11.7285	1.2520	78.6988	0.2020	0.0072	0.2591	1.5069	0.0267	0.0531	0.6801	0.0169	0.0393	0.1223	0.0732	0.6087	1.5022	0.4801
HON	95.3173	1.3450	13.1122	22.0797	0.8335	58.7319	0.1252	0.1658	1.0465	0.1475	0.0000	0.0416	0.0578	0.0150	0.1995	0.2190	0.2320	0.0406	1.6073
	96.3923	1.3789	13.0306	21.9023	0.9825	58.1055	0.1629	0.3396	1.2975	0.1459	0.0231	0.1799	0.0607	0.0566	0.2143	0.2327	0.2333	0.0552	1.5984
	96.4063	1.3823	13.0289	21.8996	0.9834	58.0976	0.1633	0.3410	1.3002	0.1460	0.0232	0.1800	0.0613	0.0567	0.2152	0.2335	0.2334	0.0557	1.5988
IND	19.0628	0.3862	3.2145	6.2009	4.1280	6.9465	73.0209	0.7856	1.1589	0.6833	0.4667	0.1570	0.0216	0.1953	0.2354	0.1995	0.4993	1.4394	0.2611
	19.2061	0.4354	3.1681	6.3656	4.1115	6.8923	72.1813	0.7989	1.4493	0.6831	0.5027	0.4346	0.0336	0.2370	0.2413	0.2000	0.5072	1.4312	0.3269
	19.2074	0.4401	3.1678	6.3649	4.1115	6.8918	72.1716	0.7995	1.4505	0.6831	0.5027	0.4362	0.0341	0.2373	0.2424	0.2004	0.5071	1.4320	0.3270
JAP	82.3744	1.4799	6.5899	4.1964	2.1129	4.2044	0.3923	76.7233	0.1056	0.2608	0.0096	0.0104	1.2366	0.2846	0.1342	0.8958	1.0896	0.1032	0.1704
	83.0161	1.8563	6.5101	4.2173	2.0895	4.2231	0.4757	75.8718	0.1428	0.2601	0.0415	0.0265	1.2327	0.2972	0.1687	1.1623	1.1288	0.1061	0.1897
	83.0308	1.8564	6.5091	4.2190	2.0907	4.2231	0.4826	75.8457	0.1519	0.2613	0.0415	0.0280	1.2339	0.2976	0.1695	1.1620	1.1288	0.1062	0.1928
KOR	6.1504	3.2369	8.9164	0.8519	3.4488	2.3502	0.1408	4.4708	72.5761	0.0473	0.0237	0.0982	0.1022	0.0417	0.0929	0.0822	0.0129	2.6560	0.8508
	6.1769	3.2229	8.9130	0.8568	3.6198	2.3445	0.1413	4.4399	72.0154	0.0673	0.0366	0.3038	0.1072	0.0438	0.1844	0.0823	0.0436	2.7278	0.8494
	6.1776	3.2231	8.9120	0.8609	3.6201	2.3446	0.1415	4.4399	72.0057	0.0685	0.0366	0.3041	0.1076	0.0441	0.1856	0.0824	0.0444	2.7282	0.8505
MAL	9.8923	0.2705	6.0895	7.4240	3.4051	3.9874	8.4152	0.1617	0.5673	65.2738	0.9482	0.7119	0.0344	0.0004	0.7822	0.9488	0.0000	0.0785	0.9011
	9.9437	0.3382	6.0632	7.4328	3.3931	3.9711	8.3714	0.3518	0.5809	64.6948	0.9523	0.7203	0.0446	0.0032	0.7754	1.0041	0.0847	0.1049	1.1133
	9.9447	0.3443	6.0621	7.4316	3.3926	3.9715	8.3710	0.3566	0.5814	64.6819	0.9524	0.7204	0.0450	0.0032	0.7754	1.0065	0.0855	0.1054	1.1133
MEX	52.8189	9.5442	19.4697	1.0089	8.8065	4.0550	0.3821	0.9757	0.4987	1.1927	51.0920	0.4262	0.6871	0.0103	0.0500	0.4512	0.1480	1.1900	0.0117
	53.1788	9.5935	19.2206	1.0125	9.0388	4.0277	0.3877	1.0170	0.7391	1.1794	50.4036	0.7463	0.7098	0.0144	0.0540	0.4501	0.1944	1.1976	0.0134
	53.1814	9.5943	19.2195	1.0147	9.0380	4.0279	0.3879	1.0189	0.7397	1.1793	50.3988	0.7464	0.7098	0.0145	0.0541	0.4501	0.1944	1.1982	0.0135
NZL	2.9808	1.0721	8.7756	2.0290	3.1531	2.9584	1.0114	1.5731	0.1303	2.9733	0.1463	75.2688	0.5718	0.0076	0.0129	0.1257	0.0402	0.0916	0.0589
	2.9860	1.0785	8.7455	2.0353	3.1608	2.9576	1.0092	1.6113	0.1532	2.9780	0.1568	75.0147	0.5871	0.0253	0.0336	0.1373	0.1056	0.1353	0.0750
	2.9861	1.0791	8.7449	2.0353	3.1606	2.9593	1.0092	1.6127	0.1536	2.9777	0.1568	75.0091	0.5871	0.0260	0.0339	0.1382	0.1058	0.1354	0.0750

	SE	AUS	CAN	CHI	CHL	HON	IND	JAP	KOR	MAL	MEX	NZl	PER	PHI	RUS	SIN	TAI	THA	USA
PER	6.3542	1.5620	8.2853	0.6997	20.1531	0.5714	0.7705	2.6196	0.3600	0.0758	2.4447	1.9540	57.7834	0.9156	0.0094	0.0230	0.3228	0.0548	1.3949
	6.3869	1.7318	8.2232	0.8843	20.0529	0.5699	0.9671	2.6316	0.3617	0.0998	2.4336	1.9475	57.2019	0.9142	0.0713	0.0483	0.3469	0.0654	1.4484
	6.3876	1.7401	8.2216	0.8842	20.0497	0.5700	0.9670	2.6349	0.3632	0.1002	2.4335	1.9480	57.1912	0.9142	0.0724	0.0485	0.3469	0.0661	1.4483
PHI	12.3388	0.1124	4.5558	10.9265	3.1642	5.7293	16.0275	0.1998	0.1692	1.7876	1.5886	3.2422	0.5709	50.4666	0.7788	0.0128	0.0167	0.0024	0.6486
	12.4052	0.1211	4.5877	10.8966	3.1577	5.6795	15.9118	0.2076	0.1963	1.7736	1.5717	3.6549	0.5802	50.0119	0.9230	0.0231	0.0457	0.0123	0.6451
	12.4066	0.1213	4.5877	10.8979	3.1571	5.6798	15.9082	0.2114	0.2020	1.7738	1.5713	3.6543	0.5801	50.0015	0.9236	0.0240	0.0477	0.0124	0.6458
RUS	18.0303	1.1182	8.1112	0.5943	9.8408	2.7469	0.7748	2.2385	0.8056	0.1930	1.1980	1.6383	2.4291	0.1848	65.4294	0.7462	1.6339	0.2792	0.0379
	18.1316	1.1416	8.0250	0.7459	9.8227	2.7344	0.7747	2.2228	0.9556	0.3307	1.1868	1.6695	2.4050	0.2531	64.7800	0.7473	1.8017	0.3207	0.0825
	18.1340	1.1415	8.0240	0.7470	9.8203	2.7422	0.7748	2.2245	0.9560	0.3307	1.1866	1.6737	2.4045	0.2555	64.7633	0.7478	1.8017	0.3231	0.0830
SIN	69.9713	0.9972	10.3076	16.8556	1.3900	8.5240	3.9962	3.3993	1.5462	3.3980	1.1908	0.3469	0.1296	0.5491	0.1394	40.8079	2.9544	0.8711	2.5967
	70.4560	1.0296	10.2125	16.6387	1.5593	8.5679	3.9737	3.6470	1.6028	3.3560	1.2185	0.5694	0.1818	0.5636	0.2223	40.2842	2.9162	0.8832	2.5736
	70.4729	1.0298	10.2121	16.6417	1.5594	8.5659	3.9774	3.6461	1.6146	3.3560	1.2179	0.5699	0.1822	0.5637	0.2235	40.2654	2.9151	0.8839	2.5755
TAI	11.0991	2.3907	4.8501	7.3784	2.5340	1.0141	0.3470	1.4114	0.0116	5.5121	0.1794	0.8633	0.4763	0.1648	1.0827	0.1372	71.1724	0.4227	0.0518
	11.1212	2.4315	4.8462	7.3830	2.5316	1.0326	0.3762	1.4702	0.0146	5.5289	0.1841	0.8599	0.5031	0.1772	1.0787	0.1422	70.8937	0.4220	0.1243
	11.1219	2.4359	4.8460	7.3835	2.5313	1.0325	0.3762	1.4731	0.0148	5.5284	0.1843	0.8598	0.5031	0.1771	1.0786	0.1432	70.8856	0.4220	0.1245
THA	11.7841	5.8844	4.7209	2.6130	2.2172	0.9029	3.0657	1.8312	3.4670	1.3067	0.8943	2.2998	0.6777	3.6447	1.8591	1.0725	0.1485	63.2946	0.0998
	11.8349	6.0622	4.6952	2.6056	2.2371	1.0120	3.0523	1.8905	3.4533	1.3397	0.8882	2.3708	0.7042	3.6612	1.8594	1.0648	0.1564	62.8317	0.1154
	11.8359	6.0617	4.6949	2.6061	2.2387	1.0128	3.0528	1.8913	3.4576	1.3398	0.8883	2.3722	0.7043	3.6610	1.8592	1.0651	0.1568	62.8210	0.1165
USA	26.8836	5.4835	48.5293	0.2431	3.8035	0.8683	0.0239	1.5014	0.2990	0.3849	5.3254	0.4125	0.4607	0.8720	0.6817	0.2310	0.1621	0.9701	29.7476
	27.1145	6.1514	47.7969	0.3163	3.7601	0.8728	0.0252	1.8905	0.3334	0.3872	5.2365	0.4559	0.4785	0.8584	0.6711	0.3001	0.2218	0.9592	29.2847
	27.1192	6.1623	47.7810	0.3189	3.7597	0.8727	0.0271	1.8980	0.3340	0.3872	5.2349	0.4575	0.4792	0.8582	0.6710	0.3020	0.2226	0.9593	29.2746

Notes: The ordering for the variance decomposition is based on the number of ‘causes’ in Table 2.; the three rows for each market are in order of the forecast period of 2, 4 and 12 weeks respectively.

Table 5
Summary generalised variance decomposition, APEC Member markets for the period 3 November 1995 to 6 October 2000: Weekly data

Member	Domestic	Regional	All other	Total
Australia	91.54	0.28	8.18	100.00
Canada	73.61	0.09	26.31	100.00
China	90.55	2.58	6.88	100.00
Chile	79.07	0.02	20.91	100.00
Hong Kong	58.73	23.72	17.54	100.00
Indonesia	73.02	2.52	24.46	100.00
Japan	76.72	9.73	13.55	100.00
Korea	72.58	7.78	19.65	100.00
Malaysia	65.27	9.44	25.28	100.00
Mexico	51.09	19.48	29.43	100.00
New Zealand	75.27	1.07	23.66	100.00
Peru	57.78	20.15	22.06	100.00
Philippines	50.47	17.83	31.70	100.00
Russia	65.43	8.02	26.55	100.00
Singapore	40.81	8.81	50.38	100.00
Taiwan	71.17	10.90	17.93	100.00
Thailand	63.29	9.09	27.62	100.00
United States	29.75	53.85	16.40	100.00
Minimum	29.75	0.02	6.88	
Maximum	91.54	53.85	50.38	
Emerging markets	66.54	10.96	22.50	100.00
Developed markets	63.78	13.94	22.29	100.00
Australasian region	83.41	0.68	15.92	100.00
Northern Asian region	72.53	10.45	17.02	100.00
Southern Asian region	58.57	9.54	31.89	100.00
North American region	51.48	24.47	24.04	100.00
South American region	68.43	10.08	21.49	100.00

Notes: Regions are defined as follows: Australasia (Australia and New Zealand), Northern Asia (China, Hong Kong, Japan, Korea, Russia and Taiwan), Southern Asia (Indonesia, Malaysia, Philippines, Singapore and Thailand), North America (Canada, USA and Mexico) and South America (Chile and Peru). Developed markets include Australia, Canada, Hong Kong, Japan, New Zealand, Singapore and United States.